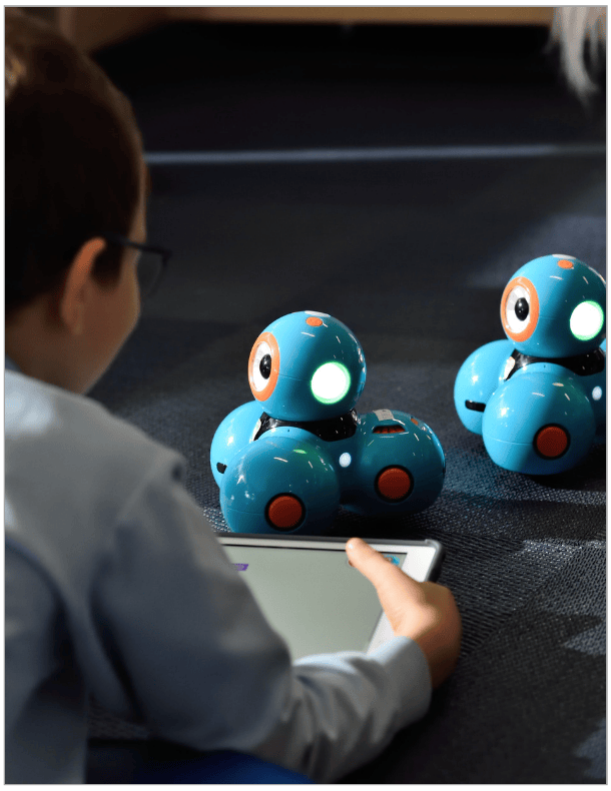
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Expanding on CS4All: Training NYC's Future Teachers to Integrate Computing Education

By training thousands more future teachers to integrate computing education in the classroom, New York City can help far more New Yorkers access technology-powered careers. Fewer than 5 percent of CUNY teacher education graduates are equipped to teach computational thinking, preventing many of the most disadvantaged students from receiving the full benefits of the Computer Science for All (CS4All) initiative.

by Eli Dvorkin and Charlotte Crowe

To build a more equitable economy in New York City, new policies and investments are needed to ensure far more New Yorkers of color, women, and low-income residents get on the path to technology-powered careers. Achieving this will only be possible by training thousands more of the city's future teachers—at all grade levels and in every subject—to integrate the core concepts of computing education into their classrooms.

Today, only a small fraction of new teachers entering New York City public schools (NYCPS) are prepared to teach computational thinking—the ability to ask questions, organize data, and solve problems with computers. Among teacher education graduates at the City University of New York (CUNY)—a group that comprises about one-third of all new teachers hired by NYCPS—experts estimate that fewer than 5 percent are equipped to teach computational thinking and digital literacies. Far from an anomaly, these low percentages are similar among graduates of other colleges of teacher education.

The scarcity of trained incoming teachers is preventing many students—in particular, Black and Hispanic students, low-income students, and girls—from experiencing the full benefits of the city's otherwise groundbreaking Computer Science for All (CS4All) initiative, which requires every student to receive four units of computer science by the end of 12th grade. Thanks to CS4All, which launched in 2015, an impressive 91 percent of the city's public schools now offer computer science classes. This has helped thousands of public-school students across the five boroughs learn the principles of computing, a crucial step on the path to a technology-powered career. However, just 17 percent of city schools are achieving CS4All's participation and equity goals.[1] In short, while more schools are offering computer science than ever before, most students are still not participating.

It will be difficult to change this without boosting the number of new teachers who are equipped to integrate computing into

their classrooms. Indeed, educational experts say that the key to getting more of the most underrepresented students to sign up for computer science classes in middle school and high school is by introducing the core concepts of computational thinking in the earliest years of a child's education. This approach builds students' confidence and sense of belonging in computing, long before they face the choice to opt into standalone classes. But even as CS4All has made progress training current teachers in computing education, far too few new teachers enter the system with these skills and abilities. As a result, New York City's public school system still struggles to ensure that most students participate in computing education—and that Black and Hispanic students and girls are represented in computer science courses in later grades.

"What we need now is a pipeline of new teachers coming into the school system every year with some ability to teach computer science," says Fred Wilson, the co-founder of CS4All and founder of Union Square Ventures, a leading venture capital firm.

No institution is better positioned to build this teacher pipeline than CUNY. Already, CUNY's education programs train far more of the city's future teachers than any other college or university, and CUNY has a promising new program—Computing Integrated Teacher Education (CITE)—that is helping train future teachers to teach computing concepts alongside other core subjects, from social studies to science. But right now, only a small share of the future teachers enrolled in CUNY's education programs are participating in courses that teach computing education.

If the CITE program expanded to reach every aspiring teacher enrolled in CUNY's education programs, an estimated 1,670 new teachers hired by New York City's public schools every year could reach more than 40,000 students annually with computing education. Seeding these teachers throughout the system—with a particular focus on teachers in grades K-6—would help spark students' curiosity, boost their confidence, and narrow equity gaps in computing education. By investing now in the city's teachers-in-training, policymakers can help ensure that these educators' future students are equipped with the foundational skills they need to pursue further computing education, succeed in tech-driven jobs, and navigate an increasingly high-tech world.

Realizing this opportunity will require a new level of city support for training aspiring teachers in computing education. To build on the promise of CS4All, Mayor Adams and the City Council should set a goal of ensuring that every new teacher is trained to integrate computing into their teaching before entering the system. City officials can help accomplish this by scaling CITE to reach all 15,000 teachers in training each year, and by launching a new Computing Education Fellowship aimed at training the next generation of educators.

Achieving a tech workforce that reflects the diversity of New York City will require new efforts to scale technology training programs, apprenticeships, and initiatives at CUNY, and stronger action from employers.[2] However, this policy brief, supported by Robin Hood, the Robin Hood Learning + Technology Fund, and Google, finds that no policy area presents city leaders with the potential for greater long-term impact than new investments in training K-12 teachers to integrate computational thinking across the K-12 curriculum.

The need for further progress toward a more equitable economy is clear. Since 2010, New York City's tech sector has added 114,000 middle- and high-wage jobs, growing by 142 percent—more than seven times faster than the city's economy overall.[3] Tech is also driving demand in many other industries, from advertising and finance to education and health care, with more than half of all new job openings in New York City requiring strong digital skills.[4] These jobs also pay very well, with fast-growing occupations such as software developers and data scientists earning a median salary of more than $135,000 per year across all industries—nearly double the city's median household income.[5] But the New Yorkers benefiting from these jobs are disproportionately white and male. Though Black and Hispanic workers make up 43 percent of the city's overall workforce, they only account for 21 percent of those in the tech sector. Women account for just 24 percent.[6]

In an effort to close the gaps—and equip more young people with the critical thinking and problem-solving skills needed to succeed in a fast-changing economy—New York City launched the CS4All initiative in 2015 with the goal of providing every student with one meaningful computer science learning experience in each grade band (elementary, middle, and high school).[7] To help achieve this goal, the initiative is on track to train 5,000 teachers already serving in the schools by 2025.

But given the scale of New York City's K-12 system, as well as churn among the city's teaching workforce, a focus on training current teachers is not sufficient to ensure that most students participate in high quality computing education. Each year, some trained teachers leave, and new teachers are hired without any training in computing education. As a result, most schools have just one or two trained teachers—a drop in the bucket for a system with more than 75,000 teachers and nearly one million students.

"If every CUNY student that is part of an undergraduate or a masters teaching program knew how to apply computing to their discipline—that would be really, really transformational," says CUNY Chancellor Félix Matos Rodriguez.

Training aspiring teachers before they enter the schools is the most effective way to expand access to integrated computing education at scale.

To reach more students with computing education, New York City's public schools first need to reach more teachers. The most effective way to achieve this at scale is to train all aspiring teachers before they enter the school system. "In-service training alone is not going to be sufficient," says Cheri Fancsali, deputy director at the Research Alliance for New York City Schools and author of a recent progress report on CS4All, referring to the professional development opportunities available to current teachers. "We have to include pre-service [training for aspiring teachers] too. Without the bedrock of teacher capacity, we can't change access and participation and ultimately student outcomes."

While CS4All has already trained nearly 4,000 teachers since 2015, that accounts for just 5 percent of teachers in the system—and it is likely that some of those trained teachers are among the estimated 5,000 teachers that leave the city's public school system every year. With few current teachers trained in computing education and even fewer aspiring teachers receiving this training, teachers with these competencies are often the only ones in their school building, or one of two, with this knowledge.

"Only having one or two teachers in a building who teach computer science doesn't work," explains Diane Levitt, senior director of K-12 education at Cornell Tech. "First of all, that's not equity. You have to win the lottery to get one of those teachers. Second, if one of those teachers leaves, either the school has no one or the other teacher is now all alone. We need whole-school implementation."

Recent research has shown that New York City public schools with multiple teachers trained to integrate computer science into classroom activities fare much better than those with only one teacher.[8] Communities of practice mitigate the challenges of teacher turnover and foster collaboration. At such schools, 75 percent of teachers say that one of their primary supports for teaching computer science is their fellow teachers, and those schools are more likely to have made improvements in CS4All implementation.[9] However, significantly boosting the number of schools with multiple trained teachers will require a major new effort to train future teachers, in addition to those already working in the system.

Recent policy changes at the state level should serve as a catalyst for accelerating this approach. In December 2020, the New York State Board of Regents adopted K-12 Computer Science and Digital Fluency Learning Standards for the first time, establishing five core computing concepts and associated standards by grade band for all students across the state[10] Ensuring that the city's schools meet these learning goals should be a major priority for city officials—and significantly expanding training for future teachers can help speed progress toward these standards, and toward achieving the larger vision of universal computing education.

"Computational thinking is an essential life skill," says Tunisia Mitchell, acting interim executive director of CS4All at the New York City Department of Education (DOE). "It's understanding how you utilize computational thinking to solve real-world problems. We want our students to understand how to apply this knowledge, use it for themselves, and choose what they want to do with it."

With thousands of newly trained teachers equipped to integrate computing education into their classrooms—not just specialized computer science teachers, but kindergarten teachers, English teachers, and science teachers, too—New York City could ensure that all children are able to build skills in computing long before self-selecting into electives and extracurricular activities.

"Introducing young people to this way of thinking in the earliest grades has a massive impact on their long-term achievement," says Richard Buery Jr., the CEO of Robin Hood, New York City's largest poverty-fighting organization. "We know that by the time they're in middle school, too many Black kids, Latinx kids, girls, have already decided that this is not for them. We have to introduce these skills early, otherwise we're creating a runway where it's too hard to catch up."

Education experts agree that in order to make computing education accessible to all students from the earliest years—and close the existing gaps in equity and participation—it should be integrated across subject areas, from math to music to language arts.[11] Teachers at all grade levels and in every discipline need to be prepared to integrate computing.

"Computer science should not be taught in silos or separate from the rest of the curriculum," stresses Councilmember Rita Joseph, who chairs the City Council's Committee on Education and previously taught for more than two decades at P.S. 6 in Brooklyn. "It should be taught as part of everything else."

CUNY trains more K-12 teachers than any other institution in New York, but needs more support to expand training in computing education for all future teachers.

CUNY offers teacher education programs at six community colleges and nine senior colleges. Of the 5,000 new teachers that the city's public schools hire every year, nearly one-third are graduates of these programs. In addition to the skills and life experiences they bring to the classroom, these graduates have the best retention rates in the system, with 80 percent of alumni teaching for more than five years compared to 62 percent from other institutions.[12] Moreover, many of CUNY's education students are New York City public school graduates themselves, hailing from the same districts and neighborhoods where an expansion of equitable computing education could achieve the greatest impact. Preparing far more of these aspiring teachers to bring computational thinking into their classrooms could therefore generate benefits for students that persist for years to come.

Through CS4All, the New York City Department of Education has established a goal of training 5,000 current teachers over ten years. By comparison, an initiative to ensure that all students enrolled in CUNY's teacher education programs learn how to integrate computing education into their pedagogy would reach approximately 15,000 students every year. At the current pace of hiring from CUNY into the city's public school system, city schools would onboard more than 8,000 new teachers equipped with these skills within five years and more than 16,000 within ten. "If we're able to affect that pipeline, there's an opportunity to make a real difference in many, many classrooms," says Aankit Patel, the director of STEM education

programs at CUNY.

The challenge, according to data gathered from interviews, is that fewer than 5 percent of CUNY teacher education graduates are trained to teach computational thinking and digital literacies today. However, a new initiative is underway with the potential to change this. That program, Computing Integrated Computer Education, has already begun to assist teacher education faculty in developing ways to incorporate computing concepts into their areas of focus, from second-grade math to fifth-grade language arts.

In turn, these faculty will equip their students—future teachers—with the skills they need to integrate computing into their practices. Teacher education faculty participating in curriculum redesigns through CITE see computing as urgent and deeply relevant to their work preparing new educators. “I believe teachers can approach computing from a place of possibility,” says Cecilia Espinosa, associate professor in the early childhood/childhood department at Lehman College. “If they think critically and computationally about what they are asking their students to do, their students can grow in their computational thinking.”

The problem is that the scale of the CITE program, which is publicly and privately funded, is limited so far (the program was initially seeded with $14 million over four years from DOE, CUNY, Google, the Robin Hood Learning + Technology Fund, and Gotham Gives). CITE has already worked with 100 teacher education faculty to help them understand how computing intersects with their work, with the goal of reaching another 100 faculty, “But even meeting that goal,” says Patel, “we’d still be at less than half the faculty that are preparing future teachers at CUNY.”

If city officials set a goal of ensuring that all pre-service teachers receive substantial training in computing education—and invest in CITE to transform all of CUNY’s teacher education programs—New York City could dramatically expand the number of teachers equipped to champion equitable computing education. Combined with expanded efforts to support professional development for current teachers and school leaders, these efforts could expand on the vital work of CS4All and ensure that thousands more young people graduate New York City’s public schools computationally fluent and prepared to participate fully in an increasingly digital world.

Recommendations

1. **Ensure that every future teacher in New York City’s public schools is prepared to integrate computational thinking into their classrooms.** Achieving New York City’s CS4All equity and participation goals will require a major new effort to train, recruit, and retain new teachers who are prepared to champion equitable computing education in their classrooms and schools.However, just a small fraction of the city’s new and aspiring teachers receive this sort of training today. The city should set a clear goal to ensure all future teachers are trained in integrated computing education, require DOE to report on progress in achieving this goal, and strengthen partnerships between DOE and CUNY to help achieve this goal by 2025.
2. **Invest in scaling up Computing Integrated Teacher Education (CITE) at CUNY to reach all aspiring teachers.** CUNY’s highly promising CITE initiative is working to equip teachers in training to integrate computing into their pedagogy, while developing these skills and connections among current education faculty. However, the program only has the resources to reach about half of CUNY’s current education faculty and lacks the scale to train anywhere close to the 15,000 aspiring teachers enrolled at CUNY. City leaders should make CITE a baseline-funded program, with a focus on ensuring that all education students receive training in equitable computing education practices. A new level of long-term support would also enable CUNY to research, test, and scale training, coaching, and leadership development programs in equitable computing education for both aspiring and current educators and school leaders.
3. **Build the pipeline of future teachers by creating a Computing Education Fellowship for teachers in training.** To help incentivize more aspiring teachers to pursue computing education—especially those

from lower-income backgrounds—Mayor Adams and the City Council should launch a new fellowship program for students pursuing teaching degrees to train in integrated computing education. Developed in partnership with the New York City Department of Education and CUNY, the fellowship would create cohorts of future computing educators who could support one another personally and professionally while training and after entering the school system. Crucially, the fellowship should include an expanded teacher residency program focused on ensuring placements in New York City public schools for CUNY student teachers trained in computing education and connecting those aspiring teachers with CS4All-trained educators currently working in the system. The fellowship should also include a scholarship award that would help make an education degree with a specialization in computing education more affordable for aspiring teachers from low-income backgrounds.

ENDNOTES

[1] "CS4All: Examining Equity in Computer Science Access and Participation in NYC Schools," Cheri Fancsali with Janice Lee, Alexandra Adair, Kathryn Hill, Edgar Rivera-Cash, and Symantha Clough, The Research Alliance for New York City Schools, October 2022, https://steinhardt.nyu.edu/research-alliance/research/cs4all-examining-equity.

[2] For further analysis of the landscape of skills-building programs and initiatives aligned with tech careers, see the Center for an Urban Future's 2020 report Plugging In: Building NYC's Tech Education and Training Ecosystem, https://nycfuture.org/research/plugging-in.

[3] Center for an Urban Future analysis of data from the Bureau of Labor Statistics Quarterly Census of Employment and Wages. This analysis uses the Federal Reserve Bank of New York's narrow definition for measuring employment in the tech sector—one that doesn't include tens of thousands of additional tech workers employed at banks, hospitals, and in other non-tech industries.

[4] Center for an Urban Future, "Preparing New Yorkers for the Tech Jobs Driving NYC's Pandemic Economy," May 2021, https://nycfuture.org/research/preparing-nyers-for-tech-pandemic.

[5] Center for an Urban Future analysis of 2021 occupational wage data for New York City, via Lightcast.

[6] To examine the racial/ethnic composition of the city's tech sector, CUF analyzed 17 tech-specific occupations, such as database administrators, web developers, and computer network architects, using data from the 2019 American Community Survey.

[7] A "meaningful" experience is defined by DOE as units of CS instruction that last at least 11 hours and are integrated into another course, or semester- or year-long stand-alone CS courses.

[8] Fancsali et al.

[9] Ibid.

[10] New York State Department of Education, "Computer Science and Digital Fluency Learning Standards," December 2020, http://www.nysed.gov/curriculum-instruction/computer-science-and-digital-fluency-learning-standards.

[11] "Computational Thinking for an Inclusive World: A Resource for Educators to Learn and Lead ," Kelly Mills, Merijke Coenraad, Pati Ruiz, Quinn Burke, and Josh Weisgrau, Digital Promise, December 2021, https://digitalpromise.dspacedirect.org/bitstream/handle/20.500.12265/138/CTForAnInclusiveWorld_DEC2021.pdf.

[12] Data provided to CUF via interviews and sourced from the Department of Education Pinpoint Files 2005-2021 and CUNY Institutional Research Database.

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